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The taxonomic status of Rufous-rumped Grassbird *Graminicola bengalensis*, with comments on its distribution and status

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We examine the taxonomic status of the three taxa of Rufous-rumped Grassbird *Graminicola bengalensis* based on a combination of morphology, mitochondrial DNA and vocalisations. We find *sinicus* and *striatus* to be extremely similar in morphology, and that *sinicus* and *bengalensis* exhibit morphological, vocal and genetic differences (due to the lack of modern records of *striatus* it was not possible to include that taxon for vocal and genetic analysis). We propose that *sinicus* be treated as a synonym of *striatus* (the latter has priority) and that there are probably species level differences between *striatus* (s.s.) and *bengalensis*.

INTRODUCTION

The Rufous-rumped Grassbird *Graminicola bengalensis* is a grassland specialist endemic to Asia. It has been found in three main, mostly disjunct, areas: northern Indian subcontinent; south-east China (including Hainan island) and northern Vietnam; and south-east Myanmar (Tenasserim) and nearby parts of Thailand (Lekagul & Round 1991, Dickinson 2003, Collar & Robson 2007). Three subspecies are currently recognised: *G. b. bengalensis* Jerdon, 1863 (hereafter *bengalensis*) in India, Bangladesh and Nepal; *G. b. striatus* Styan, 1892 (hereafter *striatus*) in Myanmar, Thailand, Vietnam and Hainan island; and *G. b. sinicus* Stresemann, 1923 (hereafter *sinicus*) in China, having been recorded in Guangdong and Guangxi provinces and Hong Kong (Cheng 1987, Carey *et al.* 2001, Dickinson 2003, Collar & Robson 2007). Although long treated as a warbler, recent molecular work has shown it to be a babbler (Alström *et al.* 2006, Gelang *et al.* 2009), more specifically placed in a clade referred to as Pellorneinae that includes e.g. *Alcippe*, *Pellorneum*, *Turdinus*, *Napothera* and *Gampsorhynchus* (Gelang *et al.* 2009). It is currently treated as Near Threatened as it is thought to be suffering substantial long-term habitat losses due to drainage, overgrazing and conversion of its grassland and wetland habitats (BirdLife International 2001).

In this paper we discuss differences in morphology, mitochondrial DNA and vocalisations between different populations of *Graminicola bengalensis* and review the taxonomic relationships between the different taxa. We were able to review morphological differences of all three taxa by examining museum specimens, but were unable to obtain genetic vocal data for *striatus* as there are no modern records of this taxon. We also summarise what is currently known regarding distribution and numerical status (Appendix).

MATERIAL AND METHODS

Morphology

Specimens of *Graminicola bengalensis* were examined at the Natural History Museum, Tring, UK (BMNH) and the Museum für Naturkunde, Berlin, Germany (ZMB). (The collection at the Institute for Zoology, Chinese Academy of Science, proved to hold no *Graminicola bengalensis* specimens.) The specimens examined comprised 13 *striatus*, three *sinicus* (including the holotype), and 51 *bengalensis*. In addition, biometric data collected from two *sinicus* trapped for ringing in Hong Kong were included. The following measurements were taken: length of wing (maximum chord), tail and bill (to skull), bill width and bill depth (at proximal edge of nostrils). Wing and tail measurements were recorded to the nearest 0.5 mm, bill measurements to the nearest 0.1 mm using digital vernier callipers. All measurements from specimens were taken by PJL. Wear to the rectrices and remiges was recorded separately using the following categories: none, slight, moderate or heavy. Plumage differences were assessed, with particular consideration given to those attributable to age, condition and wear. Statistics were calculated in Excel (Microsoft Inc.).

DNA extraction and sequencing

Total genomic DNA was extracted from blood or feathers from two specimens each of *bengalensis* and *sinicus* (*striatus* was not examined). Amplification and sequencing was done as in Olsson *et al.* (2005), except that products were purified using EZNA cycle pure kit (Omega bio-tek) and sequencing was done by Macrogen Inc.

Distance analysis

Sequences were aligned in MegAlign 4.03 in the DNAstar package (DNAstar Inc.), which also calculated uncorrected p distance. We also calculated distances under the HKY model (Hasegawa *et al.* 1985) which was the best-fit model according to the Akaike Information Criterion (Akaike 1973) in the same way as in Olsson *et al.* (2005).

Vocalisations

Analysis of vocalisations was carried out based on recordings of *bengalensis* made by Paul Holt at Chitwan, Nepal, and at Kaziranga National Park, Assam, India, and of one individual *sinicus* by GJC in Hong Kong, People's Republic of China. It was not possible to obtain recordings of *striatus*. Vocalisations were recorded using HHB PDR 1000 DAT recorder and a Telinga Pro 5 in the case of *bengalensis* and HHB Portadisc MDP 500 and Telinga Pro 5 in the case of *sinicus*. Spectrograms were prepared using Raven Pro 1.3.

Table 1. Means of length, maximum and minimum frequencies and frequency range of three song strophes each of one *sinicus* and one *bengalensis*.

	1	2	3	Mean	SD
sinicus					
length (secs)	1.11	1.17	1.22	1.17	0.06
max freq. (kHz)	4.80	4.64	4.48	4.64	0.16
min freq. (kHz)	1.80	2.00	2.00	1.93	0.12
frequency range (kHz)	3.00	2.64	2.48	2.71	0.27
bengalensis					
length (secs)	1.36	1.40	1.47	1.41	0.06
max freq. (kHz)	4.42	4.55	4.64	4.54	0.11
min freq. (kHz)	1.57	1.52	1.59	1.56	0.04
frequency range (kHz)	2.85	3.03	3.05	2.98	0.11

RESULTS

Morphological differences

Plumage differences between all three taxa are detailed in Table 2. We found *striatus* and *sinicus* to be extremely similar, with the only consistent difference being the slightly narrower pale fringes to the mantle feathering in *sinicus*. However, *bengalensis* is readily separable from both *striatus* and *sinicus* by having broader pale fringes to the tips of all the rectrices, and blacker and more extensive streaking on the mantle and crown, with white rather than rufous fringes to these feathers. This results in *bengalensis* being much more contrasting above than both *striatus* and *sinicus*. It should be noted that these differences are less apparent in birds in very fresh plumage, as all three taxa exhibit rufous fringes to the upperparts and a rufous wash to the underparts. In such plumage the most obvious difference between *bengalensis* and *striatus*/*sinicus* is the width of the pale tips to the rectrices. However, the rufous fringes above abrade very rapidly and these fringes are not apparent in skins with even slight wear.

Biometrics of males and females are not significantly different in any taxon, except bill length in *bengalensis*, which differs between the sexes (two-sample heteroscedastic t-test, p=0.017). The following measurements of both sexes combined are significantly different (two-sample heteroscedastic t-test): tail *striatus–sinicus* (p=0.038); bill depth *striatus–bengalensis* (p=0.00001) and *sinicus–bengalensis* (p=0.0016); bill width *striatus–bengalensis* (p=0.01) and *sinicus–bengalensis* (p=0.03). See Table 3. Differences in bill measurements are shown in Figure 1.

Genetic analysis

We obtained contiguous 1,076 base pair portions of the cytochrome *b* gene from two specimens each of *bengalensis* and *sinicus*. No frameshift mutations or stop codons that would indicate the accidental amplification of nuclear pseudogenes (e.g. Zhang & Hewitt 1996, Sorensen & Quinn 1998) were detected. The sequences are deposited in GenBank under the accession numbers HM628906 (Hong Kong), HM628907 (Hong Kong), HM628908 (Nepal) and DQ008480 (Nepal). Genetic distances are given in Table 4.

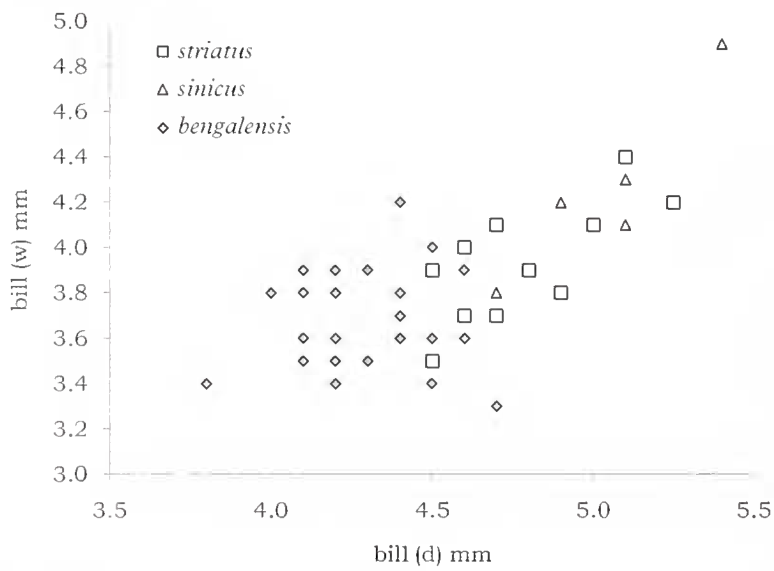

Figure 1. Scatterplot comparing bill width and depth (measured at proximal edge of nostrils) of *bengalensis*, *striatus* and *sinicus*.

Table 2. Plumage comparison of *bengalensis*, *striatus* and *sinicus*.

	bengalensis	*striatus*	*sinicus*
Crown	Striped buff and black; black stripes clearly broader than buff stripes. Black streaks prominent on forecrown	Striped rufous and blackish; blackish streaks narrower than rufous streaks. Blackish streaks becoming diffuse on forecrown	Striped rufous and blackish; blackish streaks narrower than rufous streaks. Blackish streaks becoming diffuse on forecrown
Nape and mantle	Nape with broad black centres and narrow white feather fringes, mantle with broad black feather centres and extensive narrow silver-white fringes; mantle predominantly black	Nape striped dark brown with grey to greyish buff fringes; stripes and paler fringes generally of even width. Mantle with broad dark brown to brownish-black feather centres with narrow rufous fringes	Nape striped dark brown with grey to greyish buff fringes; stripes and paler fringes generally of even width. Mantle with broad dark brown to brownish-black feather centres with narrow rufous fringes. Pale fringes less extensive than in *striatus*
Rump and uppertail-coverts	Extensive narrow blackish streaks, especially on upper tail coverts	Dark brown streaks on uppertail-coverts of some birds, largely unstreaked on rump and uppertail-coverts	Unstreaked on rump, dark brown streaks on uppertail-coverts
Flanks and undertail-coverts	Rufous	Rufous	Rufous
Tail	Upperside of central feathers grey-brown with prominent darker centre along entire length, broad white tips	Upperside of central feathers brown-grey with indistinct or no darker centre along length, narrow off-white tips	Upperside of central feathers brown-grey with indistinct or no darker centre along length, narrow off-white tips

Table 3. Biometrics of *bengalensis*, *striatus* and *sinicus*, given in the order mean, ± standard deviation, number (in parentheses). M: male; F: female; A: all. Significant differences (t-test, sexes combined) between *bengalensis* and the two others are indicated by asterisks: * P ≤0.05, ** P ≤0.01, *** P ≤0.001. The only significant difference between *sinicus* and *striatus* is tail length (*). † Only two sexed specimens, both females.

		Wing	Tail	Tarsus	Bill (to skull)	Bill depth	Bill width
bengalensis	A	59.67 ± 1.62(43)	78.36 ± 3.90(35)	24.58 ± 1.03(13)	16.06 ± 0.59(33)	4.26 ± 0.21(31)	3.68 ± 0.21(29)
	M	59.9 ± 1.58(13)	77.7 ± 5.26(12)	24.5 ± 0.83(4)	16.49 ± 0.50 (11)	4.31 ± 0.32(10)	3.52 ± 0.21(9)
	F	60.0 ± 2.27(8)	79.3 ± 2.17(5)	24.3 ± 1.41(3)	15.75 ± 0.63(8)	4.27 ± 0.18(6)	3.68 ± 0.13(5)
sinicus †	A	58.90 ± 2.07(5)	79.94 ± 2.87(5)	24.73 ± 0.99 (3)	16.46 ± 0.62(5)	5.04 ± 0.26 (5)**	4.26 ± 0.40(5)*
striatus	A	60.59 ± 1.81(11)	76.00 ± 2.93(9)	24. 07 ± 1.09(11)	16.12 ± 0.66(11)	4.79 ± 0.25(11)***	3.94 ± 0.26(11)**
	M	61.6 ± 1.85(5)	76.1 ± 1.65(4)	24.08 ± 1.20(5)	16.48 ± 0.44(5)	4.82 ± 0.13 (5)	3.92 ± 0.18(5)
	F	59.7 ± 1.57(5)	75.0 ± 3.83(4)	23.80 ± 0.99 (3)	15.70 ± 0.69(5)	4.79 ± 0.36 (5)	3.68 ± 0.34(5)

Table 4. Genetic distances between representatives of two populations of *Graminicola bengalensis*.

a. Genetic distances (%; uncorrected p).

	bengalensis Nepal 1	*bengalensis* Nepal 2	*sinicus* Hong Kong 1	*sinicus* Hong Kong 2
bengalensis Nepal 1	–			
bengalensis Nepal 2	0.1	–		
sinicus Hong Kong 1	2.6	2.5	–	
sinicus Hong Kong 2	2.6	2.5	0	–

b. Genetic distances (%) calculated under the HKY85 model.

	bengalensis Nepal 1	*bengalensis* Nepal 2	*sinicus* Hong Kong 1	*sinicus* Hong Kong 2
bengalensis Nepal 1	–			
bengalensis Nepal 2	0.1	–		
sinicus Hong Kong 1	2.7	2.6	–	
sinicus Hong Kong 2	2.7	2.6	0	–

Vocalisations

The taxon *sinicus*, at least, appears to utter song relatively infrequently, and only one recording was obtained in eight early morning and late afternoon visits to the breeding area over two breeding seasons. Despite this, the vocal repertoire of both taxa appears to be fairly wide, and includes a variety of moderately modulated, high-pitched and churring calls, at times recalling a shrike *Lanius*. However, what is considered to be the primary song for both taxa is a fairly rapid and musical, somewhat jaunty and rhythmic utterance that lacks any churring notes. While similar across the two taxa, the two songs are recognisably different (Figs. 2–3).

The initial notes of each strophe of *sinicus* are not recognisably distinct from the rest, while the initial note of each strophe in *bengalensis* is rather more distinct, being quieter and less musical, and there is a short gap before the rest of the strophe is uttered; overall, this imparts a more hesitant introduction. Each strophe ends with two very similar notes, which are usually terminally flat in pitch in *sinicus* but inflected in *bengalensis* (Figs. 2–3).

The mean length of the three strophes analysed for *sinicus* was shorter than the mean of the three strophes of *bengalensis* (Table 1). Peak frequency of *sinicus* averaged 4.64 kHz, while the minimum averaged 1.93 kHz; the equivalent values for *bengalensis* were 4.54 kHz and 1.56 kHz (Table 1). The song strophes of *sinicus* had a mean frequency range of approximately 2.71 kHz, while that of *bengalensis* was approximately 2.98 kHz (Table 1). This combination of longer strophes uttered more rapidly at a slightly higher pitch with an inflected termination in *bengalensis* creates a fairly distinctive difference between the two. Both *sinicus* and *striatus* utter similar harsh, churring calls when agitated or alarmed. However, those of *sinicus* (Fig. 4) tend to be slightly higher in pitch, usually as high as 4.5 kHz, whereas those of *bengalensis* (Fig. 5) generally do not exceed 4.0 kHz.

There appear to be distinct differences in the vocalisations of these two taxa and these may prove significant with a larger sample size.

Song flight

Song flight has been recorded in *bengalensis* breeding in Nepal by Baral *et al.* (2006), who noted that while singing

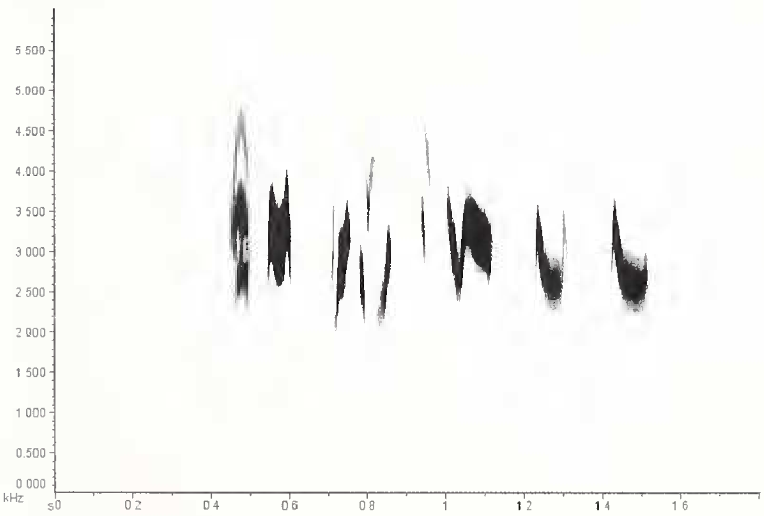

Figure 2. Song strophe of *sinicus*. 15 May 2008, Robin's Nest, New Territories, Hong Kong, China (Geoff Carey).

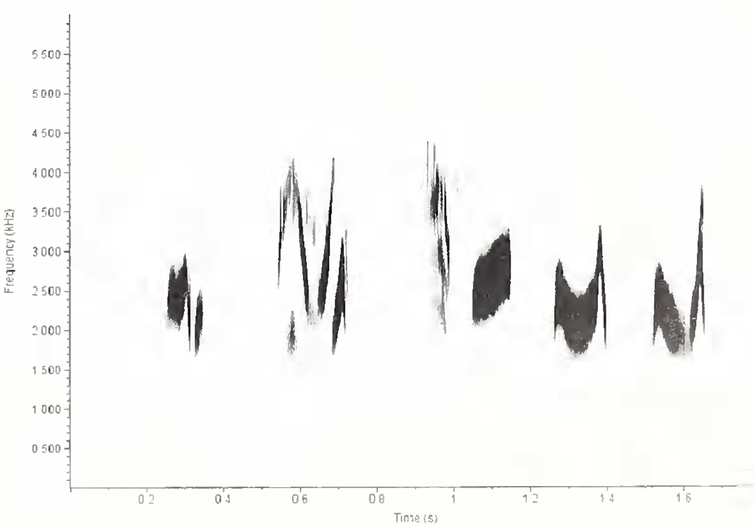

Figure 3. Song strophe of *bengalensis*. 17 March 2001, near Sauraha, Chitwan National Park, Nepal (Paul Holt).

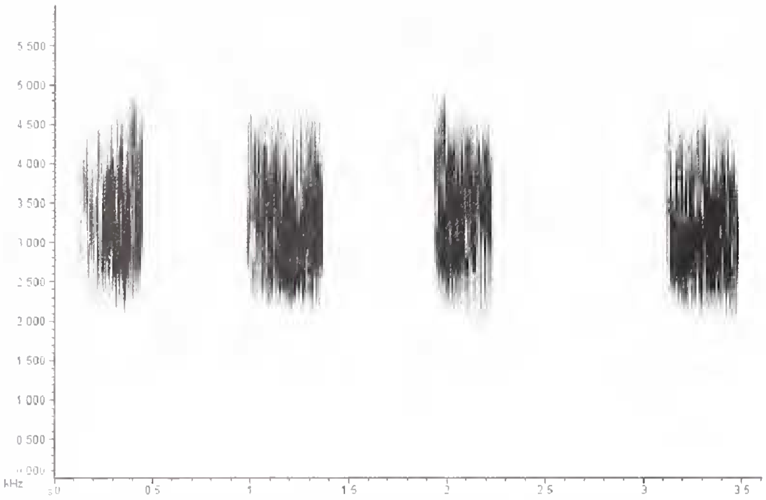

Figure 4. Harsh, churring calls of *sinicus* uttered when agitated or alarmed. 28 May 2008, Robin's Nest, New Territories, Hong Kong, China (Geoff Carey).

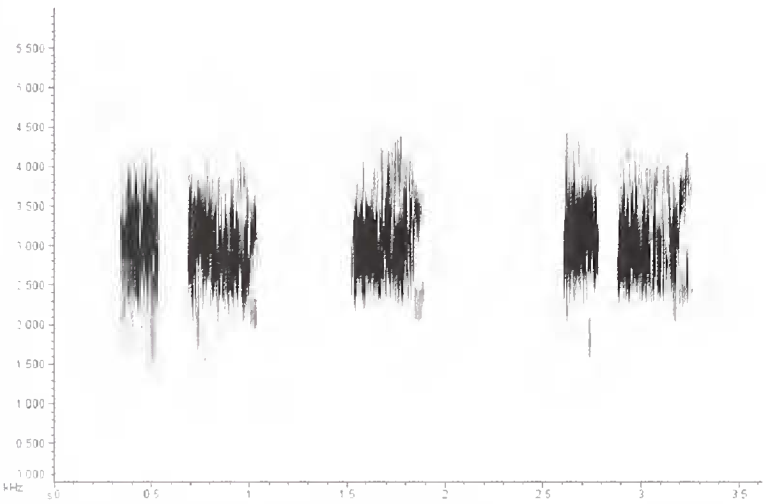

Figure 5. Harsh, churring calls of *bengalensis* uttered when agitated or alarmed. 23 March 1999, near Sauraha, Chitwan National Park, Nepal (Paul Holt).

birds usually remain well concealed, in the breeding season, they occasionally perform a short song flight to a height of about 3 m above grass height, which was not as elaborate as the flights of Striated Grassbird *Megalurus palustris* or Bristled Grassbird *Chaetornis striatus* (Baral 1997). In addition, a horizontal branch-to-branch flight with song emitted has also been recorded (HSB pers. obs.). In Hong Kong, China, *sinicus* invariably sings from patches of tall grass or from within dense vegetation and has never been noted in song flight either by us or by a number of Hong Kong birdwatchers we consulted.

DISCUSSION

Based on plumage characters and bill structure, *bengalensis* can be differentiated from both *sinicus* and *striatus*, while the latter two are only very subtly different. Of the biometrics reviewed we found that *bengalensis* has a significantly less deep and less wide bill than *striatus* and *sinicus*, while the latter two are very similar, with the only significant difference being in tail length.

When describing *sinicus*, Stresemann (1923) noted that it was larger than *bengalensis* and *striatus* (wing 62 mm) and was distinguished from either by the jet black rather than light brown feather-shafts to the breast feathers. The colour of upperparts, head and tail of *sinicus* were described as similar to *striatus*, while flanks and undertail-coverts were darker chestnut than *bengalensis*. Certainly, a wing of 62 mm is large for a Rufous-rumped Grassbird; however, it is within the range for all three taxa. An examination of the type specimen of *sinicus* at the ZMB showed that it is in very fresh plumage (very slight wear on the primaries); as discussed above, birds of all three taxa are more similar morphologically when in very fresh plumage. However, a comparison of other specimens of both *striatus* and *sinicus*, particularly when birds in similar states of wear are compared, leads us to the conclusion that *sinicus* is morphologically very similar to *striatus* (Tables 1 and 2). Specimens of *striatus* from Thailand and Hainan, China (the latter being the type locality of *striatus*, although the type was not examined), and of *sinicus* from Guangdong and Hong Kong, China, were examined, and no consistent morphological differences from these locations were detected. There is a recent record from western Guangxi (see Appendix) that is not ascribed to taxon and which lies within a gap in the published distribution of *striatus* and *sinicus*. This may suggest that *striatus* and *sinicus* formerly had continuous ranges and that any differences are merely part of a (subtle) cline. Based on these findings we prefer to treat *sinicus* as a junior synonym of *striatus*. The genetic distances between *bengalensis* and *sinicus* indicate that these two taxa have been evolving as separate evolutionary lineages for 1.24–1.50 million years, assuming 1.8–2.1% divergence per million years. The validity of the '2% rule' has been questioned (Garcia-Moreno 2004, Lovette 2004, Ho *et al.* 2005, Penny 2005), but Weir & Schluter (2008) showed that molecular evolution occurred in an approximately clock-like manner through time across a variety of bird lineages, and that a divergence of 2.1% per million years seems a reasonable approximation in the absence of calibration points.

With the caveat of the small sample size analysed for this work, vocalisations of *sinicus* and *bengalensis* appear to differ, providing further support to the significance of these separate evolutionary lineages.

CONCLUSIONS

We found that *sinicus* shows only very minor differences from *striatus* in terms of morphology (genetic and vocal differences were not possible to determine due to a lack of modern records from within the range of *striatus*). We recommend that *sinicus* is synonymised with *striatus* (*striatus* predates *sinicus* by 31 years).

We further found that *bengalensis* and *striatus* (including '*sinicus*') can be separated morphologically, genetically and, potentially, vocally. There also appear to be behavioural differences in that the song flight has only been recorded in *bengalensis*. We note that further research is required into the extent of the vocal and behavioural differences discussed above, but conclude that the available information indicates that *bengalensis* and *striatus* are better treated as specifically distinct.

We propose the following English names, both of which are taken from the country in which the type specimens were collected:

- Indian Grassbird *Graminicola bengalensis* Jerdon, 1863
- Chinese Grassbird *Graminicola striatus* Styan, 1892

Rufous-rumped Grassbird *Graminicola bengalensis* (*sensu lato*) is considered Near Threatened (BirdLife 2001); if the treatment proposed above is adopted then it seems likely that one or both of *bengalensis* and *striatus* warrant a higher threat status. The current distribution and status of both are summarised in the Appendix.

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APPENDIX
Current distribution and status of *Graminicola bengalensis* and *G. striatus*

Obtaining population estimates is problematic, and a number of authors comment along the lines that *Graminicola* is under-recorded or difficult to detect due to its skulking nature. However, it is also possible that it is rarely recorded at certain sites as it is present in very low densities. Baral *et al.* (2006) found it to be very vocal (and thus more easily detected) when occurring at relatively high densities; this is in stark contrast to the (low density) populations in Hong Kong which vocalise irregularly and are difficult to detect. It is to be expected that the species is more widespread than the records below suggest and observers are encouraged to search in areas of suitable habitat within the ranges of the two species.

Graminicola bengalensis

According to available data the core part of the range of *bengalensis* is Nepal, where important populations are found from Sukila Phanta in the west to Chitwan in the central region (Inskipp & Inskipp 1991). Baral *et al.* (2006) conducted a detailed study covering the status and distribution in Nepal. They found it to be a fairly common breeding resident within protected areas, especially in Sukila Phanta and Royal Chitwan National Park, but rare at Koshi Tappu and Bardia. It occurred in higher densities in open grasslands and in grasslands away from forests. At Bardia they noted that further surveys were required, as a brief visit in March 1998 coincided with heavy grass burning which may have biased the results; whilst in Koshi Tappu most of the suitable grassland habitat is degraded and lost. They concluded that the results of the study show that Nepal's lowland grasslands hold an internationally important part of the world population of *G. bengalensis*.

It is very rarely reported from India. It is known from several sites including Dudhwa National Park (Uttar Pradesh), and Dibru-Saikhowa (Assam). At the latter site it was 'rarely seen' (Allen 2002). Although Barau & Sharma (1999) state that it is occasionally seen at Kaziranga National Park, Robson (2007) notes that recent reports from protected areas in north-east India indicate a good population in this park. Singh *et al.* (1999) recorded it from D'Ering, the only records from Arunachal Pradesh.

In Bangladesh it has recently been recorded in low numbers in the north-east by Thompson & Johnson (2003) who noted that the 'only remaining suitable areas of wet grassland would appear to fringe some of the hoars in the north-east region...'; Collar & Robson (2007) note that it has disappeared from most of its range within Bangladesh due to habitat destruction.

There are six specimens from Bhutan ('Bhutan Duars') in BMNH. As Bhutan does not appear to be within the published range of *Graminicola bengalensis*, these specimens are of note.

Current population estimates **India**: Rarely reported and localised; population unknown but on current information considered to be low. **Bangladesh**: Rarely reported and localised, restricted to the north-east; population presumed to be very low. **Nepal**: Using a density estimate of 10 pairs/km^2, and area of potential grassland habitat based on site visits, verification from the maps and field experience, the population in Nepal is estimated to be approximately 2,000 pairs (HSB unpubl. data).

Graminicola striatus

In certain parts of its range it has suffered significant losses and is now thought to be extinct in both Thailand (last record 1923: Lekagul & Round 1991, Collar & Robson 2007) and Vietnam, where there is little if any suitable habitat remaining (BirdLife International 2001, P. D. Round and J. Eames pers. comm.). There are no modern records from Myanmar, despite recent extensive surveys of suitable habitat (J. Eames pers. comm.).

In China it has not been recorded from Hainan since 1899 and there are very few recent records away from Hong Kong. In Guangxi there has been one record since 1931, concerning one in Shiwandashan, south-west Guangxi, at 600 m, May 1997 (Lee *et al.* 2006, Lee Kwok Shing *in litt.*). There are two older records from Guangdong: one undated (at the South China Institute of Endangered Animals: R. W. Lewthwaite pers. comm.), the other from 1917 (Stresemann 1923). There is one recent record of two at 900 m at Wutongshan, Shenzhen, on 17 May 2001 (Lee Kwok Shing *in litt.*). In Hong Kong it is considered to be a scarce grassland specialist breeding at 200–800 m (Carey *et al.* 2001).

Current population estimates **Myanmar**: No modern records, population presumed to be very low. **Thailand**: No modern records; presumed extinct. **Vietnam**: No modern records; presumed extinct. **China**: Recent widespread surveys of many sites with suitable habitat in Guangdong, Guangxi and Hainan provinces have generated single records each in Guangxi and Guangdong (Lee *et al.* 2006, Lee Kwok Shing *in litt.*). The population level in these areas is presumed to be low, although it seems likely that there are numerous other sites at which birds remain to be discovered. In Hong Kong it is restricted as a breeding species to grasslands at 200–800 m, and during a territory-wide breeding bird survey during 1993–1996 it was recorded in 13 1 km squares out of a total of 1,220 1 km squares surveyed (present in 0.1% of squares) (Carey *et al.* 2001). The stronghold appears to be the Tai Mo Shan massif, where it was found in four 1 km squares during the survey. Even in optimum breeding habitat, however, it occurs at low densities (estimated to be 1–2 pairs per km^2), and it is likely that the Hong Kong population is not large. During a census of wintering birds during 2001/2002 to 2004/2005 a total of 18 individuals were recorded in 10 1 km squares (Hong Kong Birdwatching Society unpublished data). Based on a review of historical data at each breeding site (Leader in prep.), it is estimated that the Hong Kong population is in the region of 50–100 pairs. Although this species was only formally identified in Hong Kong in 1978 it is thought to have been present since at least 1957 (Melville & Chalmers 1984). Recent visits to Tai Mo Shan and Robin's Nest in Hong Kong indicate that regeneration of shrubland, tree planting and grazing by feral cattle are reducing the area of suitable breeding habitat for this species. A Hong Kong-wide study mapping terrestrial habitats found that the area of grassland decreased from 25,752 ha in 2003 to 21,572 ha in 2004 (Scott Wilson 2005); during the same period the area of shrubby grassland (i.e. the next successional stage) increased from 14,332 to 24,674 ha, which the study attributed to a genuine increase in the size of the habitat. Regeneration of shrubland and tree planting are also thought to be issues at other grassland sites in Hong Kong, Guangdong and Guangxi.